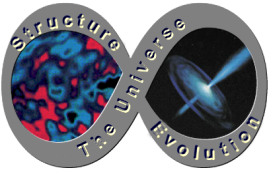




BOOMERANG:
Sub-Orbital Precursor to the *Planck Surveyor*
(Planck Surveyor on a Rope)

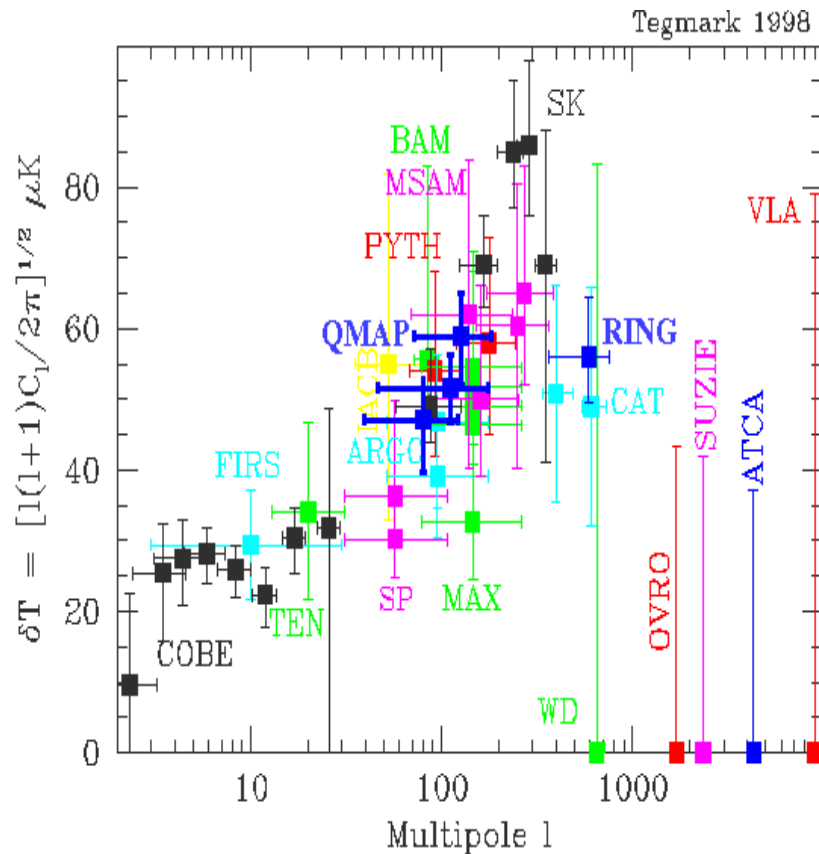
Jamie Bock
Jet Propulsion Laboratory

<http://www.physics.ucsb.edu/~boomerang/>



BOOMERANG Science Goal:

Resolve the spatial structure in the CMB



- **Size and amplitude of structures not resolved by COBE should yield accurate measurements of most cosmological parameters (Ω , Ω_m , Ω_Λ , H_0 , ...)**
- **Need both high angular resolution and sensitivity to detect these features**

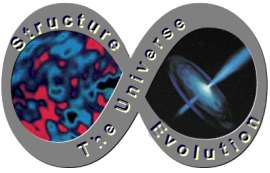


The Ideal Sub-Orbital Environment:

Antarctic Long Duration Ballooning (LDB)

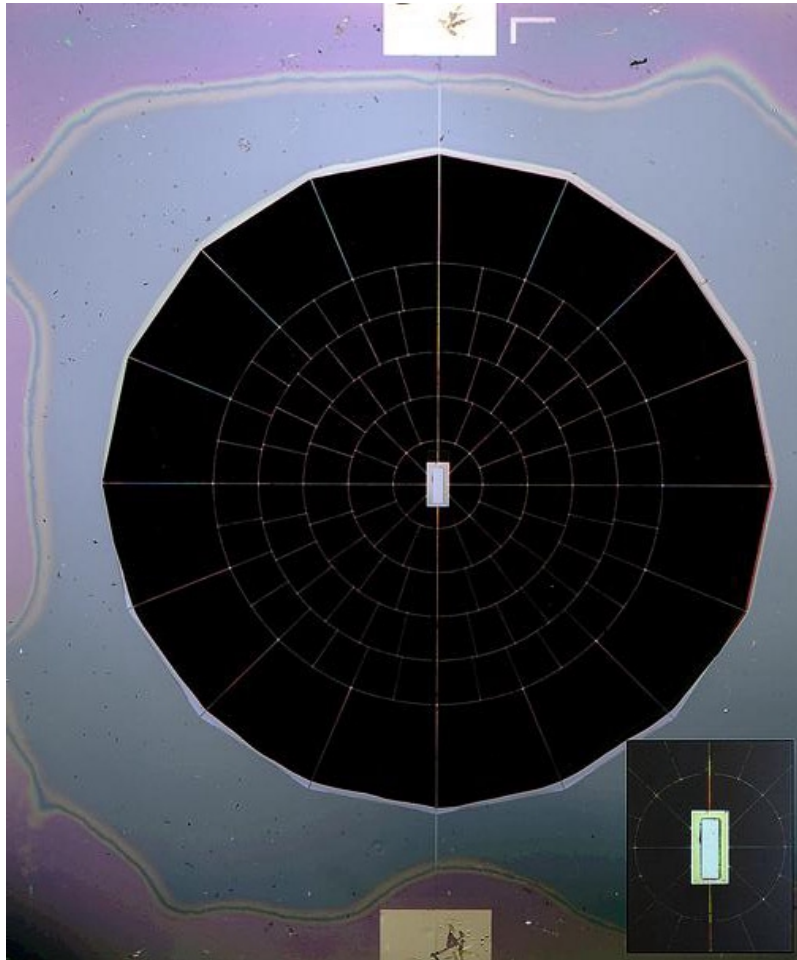


- 10+ days at 120,000 ft
- Continuous TDRSS link
- Orbit-like Environment
 - Negligible atmospheric emission
 - High cosmic ray flux
 - High temperature gradients
 - Challenging EMI/RFI
 - Challenging Launch Ops



Sub-Orbital Enables Orbital:

Technology

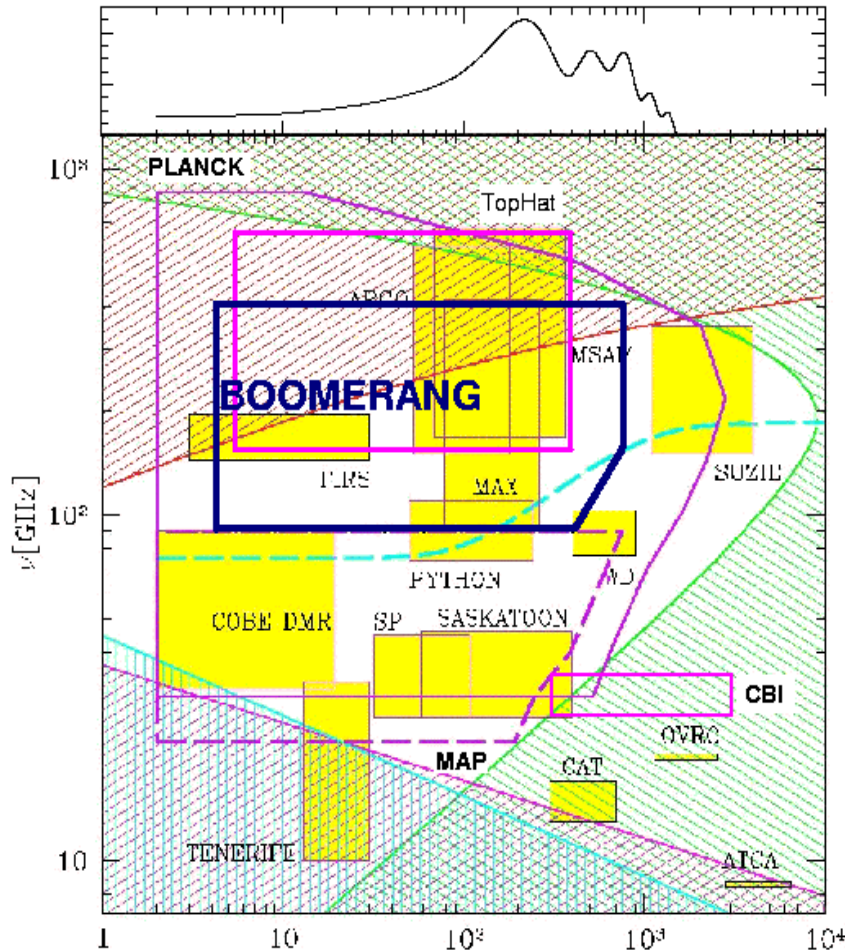


- “Spider-web” bolometer architecture originally motivated by Antarctic LDB observations (low cosmic ray cross-section)
- LDB-driven technology enabled the Planck Surveyor (and secured U.S. role in this mission)
- Arrays of “spider-web” detectors now developed at JPL are under study for FIRST

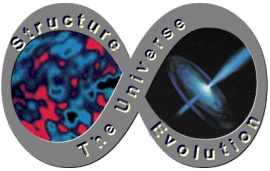


Sub-Orbital Enables Orbital:

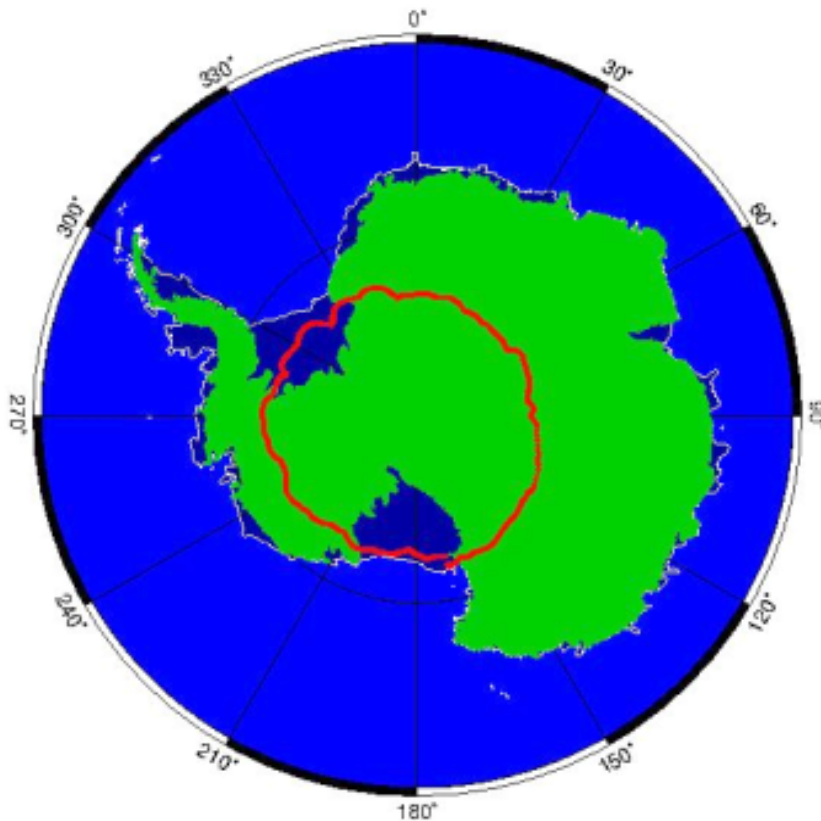
Science



- **BOOMERANG (1999)** :
90, 150, 220, 440 GHz
10' resolution
- **Complements MAP (2000)**:
20, 30, 45, 60 and 90 GHz
12' resolution
- **Enables Planck (2007)**:
30, 45, 60, 100, 150, 220, 350,
550, 850 GHz
5' resolution



BOOMERANG: 98/99 LDB Flight

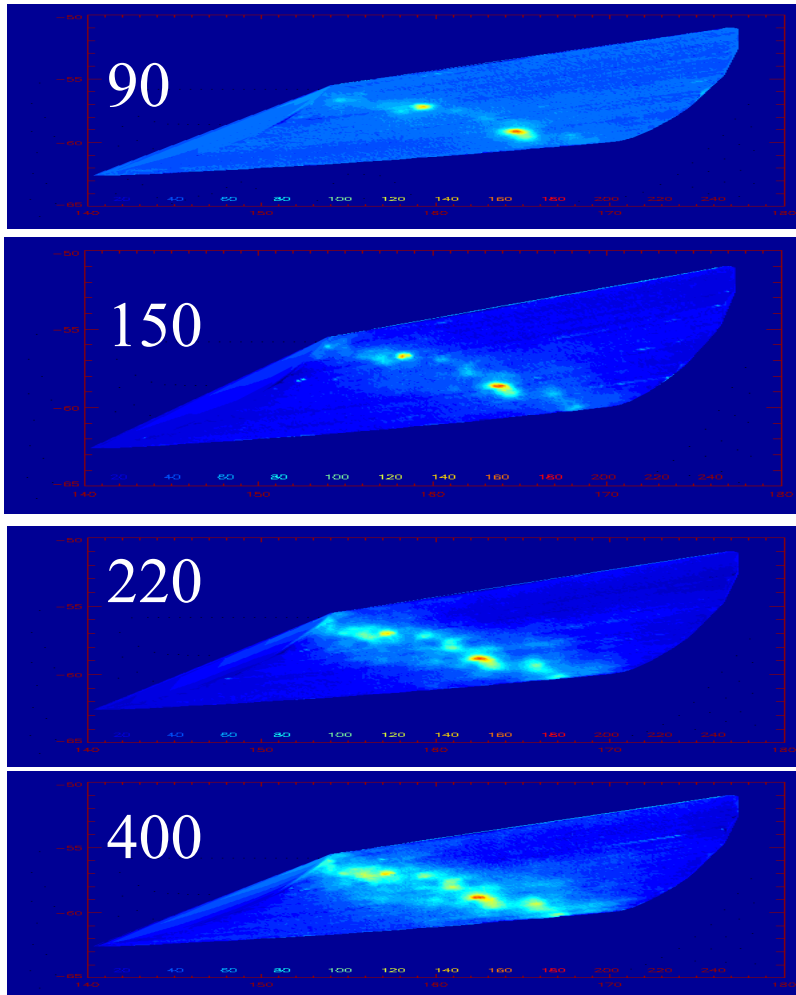


GMT 98/99 LDB_Antarctica

- 10.5 days of continuous and flawless observation
- Instantaneous sensitivity:
 - ~ 100x COBE
 - (1 LDB day = 20 COBE years!)
- Angular resolution:
 - ~40x COBE
- TDRSS link allowed real-time analysis and control
- Payload recovered intact 50 km from launch site

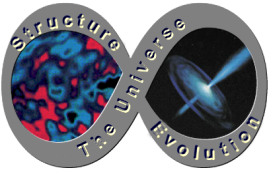


***BOOMERANG* Preliminary Results I:**



- **First high resolution maps of mm-wave Galactic emission:**

- confirm “window” in galactic emission at 90, 150 GHz, excellent correlation with IRAS
- constrain effects of dust contamination on *MAP*, *Planck Surveyor*



BOOMERANG Preliminary Results II:

Figure: First high S/N, resolved
images of CMB anisotropies

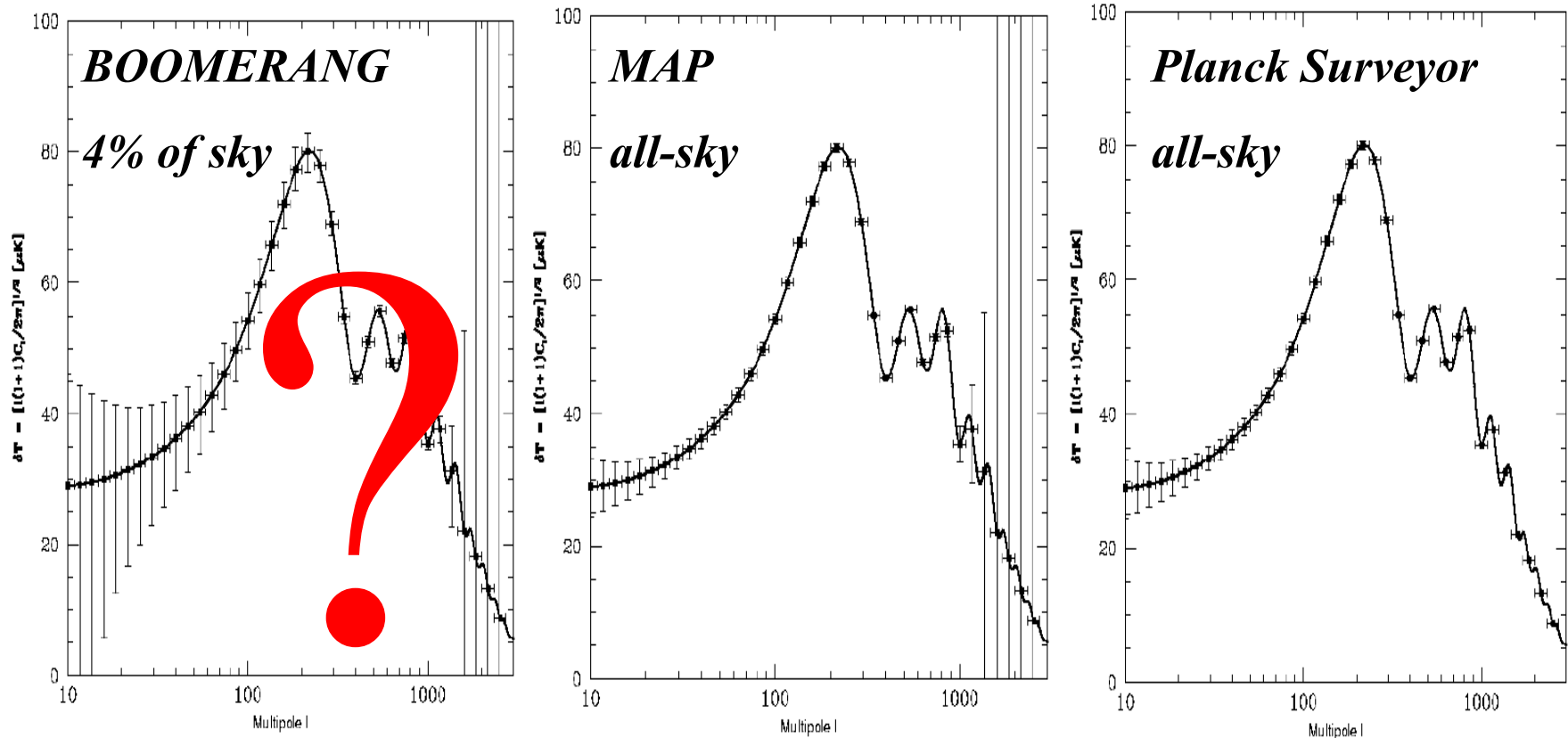
(proprietary image - will be
shown on May 18, 1999)

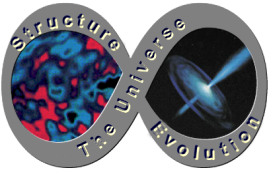
- Sub-Kelvin
“Spider Web”
bolometers +
LDB = **first
high signal-to-
noise ratio,
resolved
images of CMB
structure**



BOOMERANG, MAP and Planck:

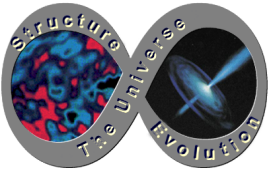
BOOMERANG achieved both high angular resolution and high sensitivity but is ultimately vulnerable to systematic effects that are vastly smaller for orbital missions. The ultimate precision with which BOOMERANG will have determined the power spectrum is not yet known. Ultimate confirmation of any result will await data from MAP, which will have exquisite control of systematics by virtue of both design and environment.





Cost of BOOMERANG

- Cost shared ~ 50/50 between U.S. (P.I. Lange) and Italy (P.I. deBernardis)
- US cost shared ~ 50/50 between NASA/NSF
- Total NASA support < \$200k/yr x 6 years



The Next Step:

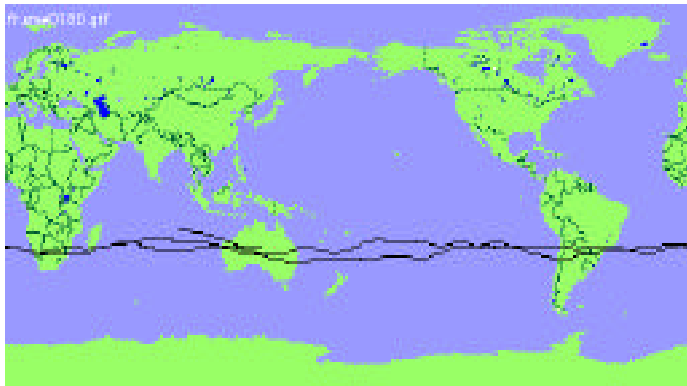
Probing Inflation via CMB Polarization

- Requires μK sensitivity on degree angular scales, beyond capability of MAP
- Flight-proven *BOOMERANG* payload recovered intact
- Modified focal plane will provide CMB polarimetry
- Re-flight in 12/00 (contemporary with MAP)
- $\sim 2 \mu\text{K}/\text{pixel}$ on $\sim 10^3$ pixels
 - (cf. *MAP* $\sim 35 \mu\text{K}/\text{pixel}$ on $\sim 10^6$ pixels)
- Technical and scientific precursor to post-*Planck* CMB polarimeter

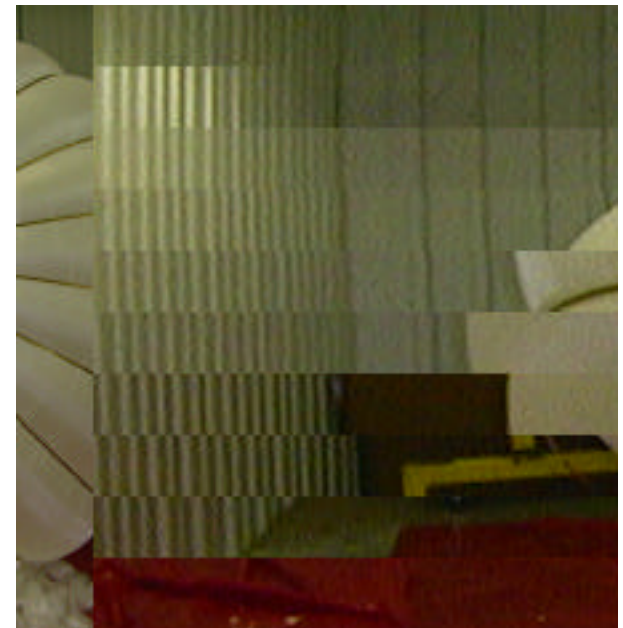


NASA Balloon Program

- **Long Duration Balloon (LDB) flights of 10 to 20 days**
 - Operational (local summer only)
 - Antarctica or Fairbanks, AL
 - Conventional balloon at high latitude
 - **Ultra Long Duration Balloon (ULDB) demo 60 to 100 days**
 - Planned for December 2001 (local summer only)
 - Christchurch, NZ
 - New super-pressure balloon
 - **Olympus Balloon >100 days**
 - Advance planning stage
 - Any time, any latitude (with latitude control)
- 



ULDB Trajectory Simulation



ULDB Hangar Test